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**G01R 31/36**

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**H2K KSX K255 K440 K453 K55Y K552**

**U1S S1822 S1834 S2078**

(56) Documents Cited

**GB 2121971 A**

**EP 0447928 A**

**EP 0391242 A**

**FR 002734061 A1**

**US 5454710 A**

**US 4888716 A**

**US 3808522 A**

(58) Field of Search

**UK CL (Edition T ) H2K KSX**

**INT CL<sup>7</sup> G01R 31/36**

**Other: Online: EPODOC, JAPIO, WPI**

(54) Abstract Title

**Monitoring battery performance during operation**

(57) An instrument for monitoring and indicating electrical battery health by comparison of in-service performance with performance measured when the battery was first installed. Data is automatically collected through accurate monitoring and recording of battery terminal voltage during normal operation, and by applying periodic calibrated loads. By comparing collected data with that collected when the equipment was new, an indication of health, relative to that when new, is given. The output may be used by machine operators and/or machine systems to avoid failure of the associated machine because of poor battery condition, to minimise the effects of a failure, and to schedule maintenance including a battery replacement strategy. The instrument may be used on a tractor or a boat.

Figure 1

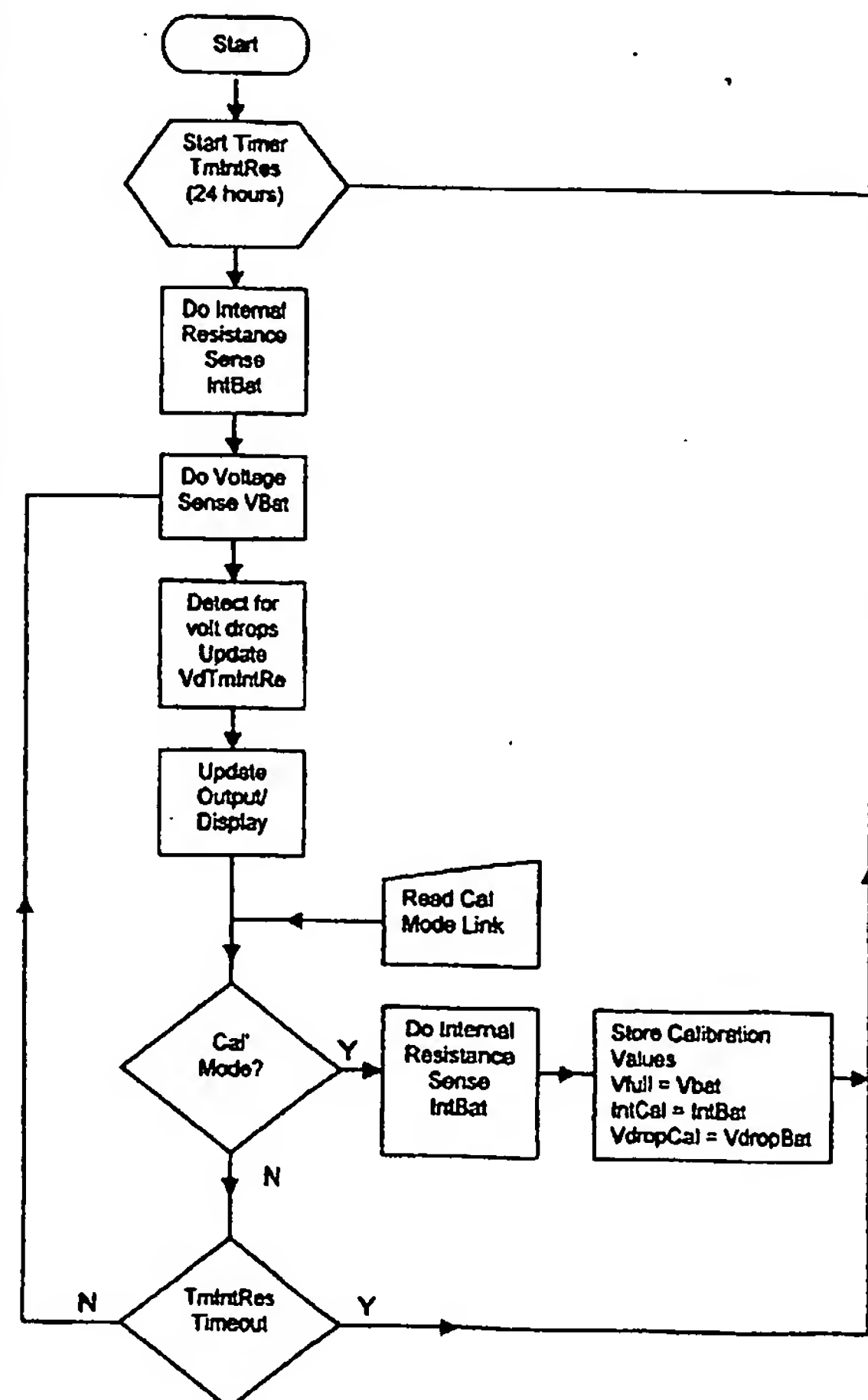


Figure 1

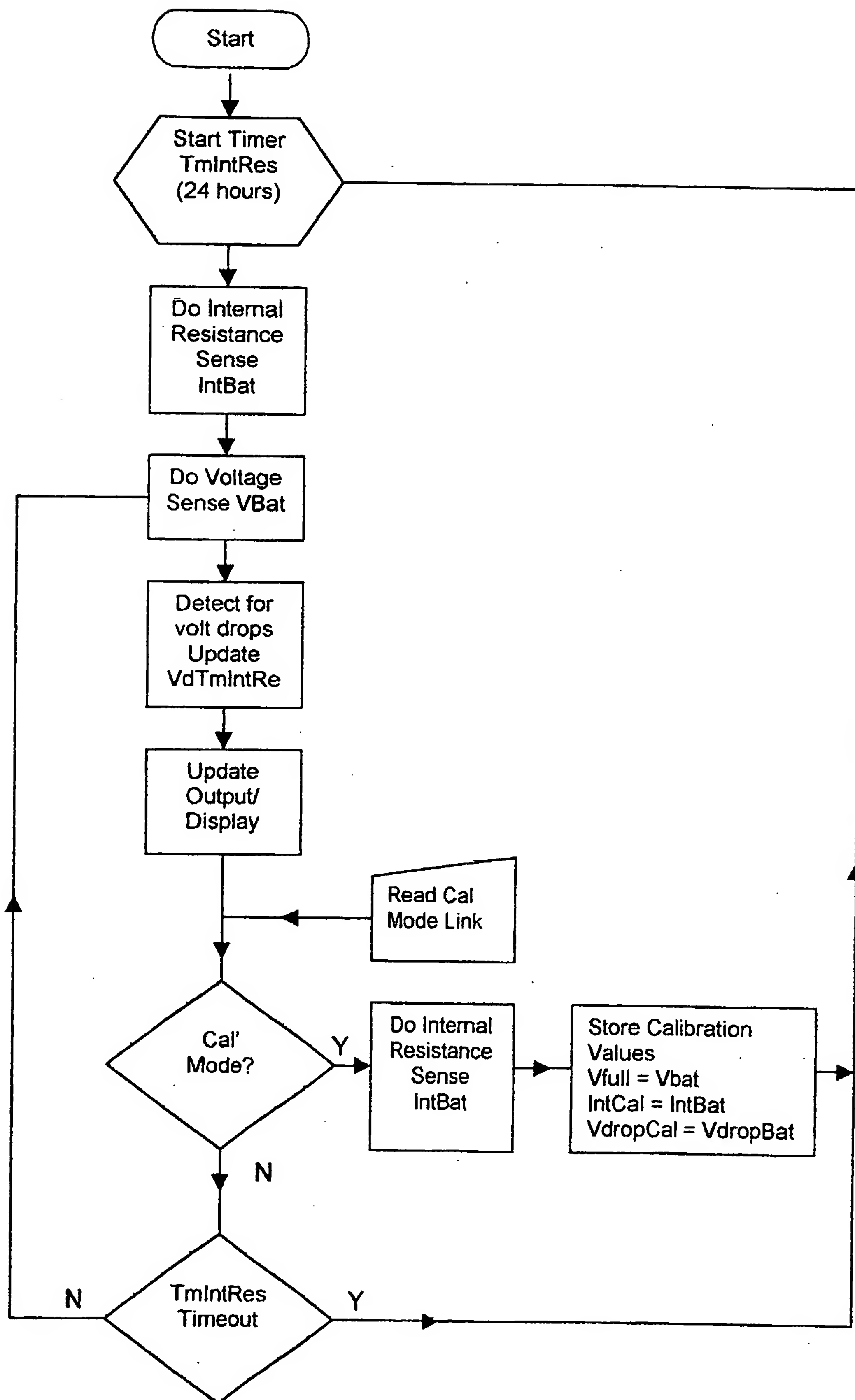
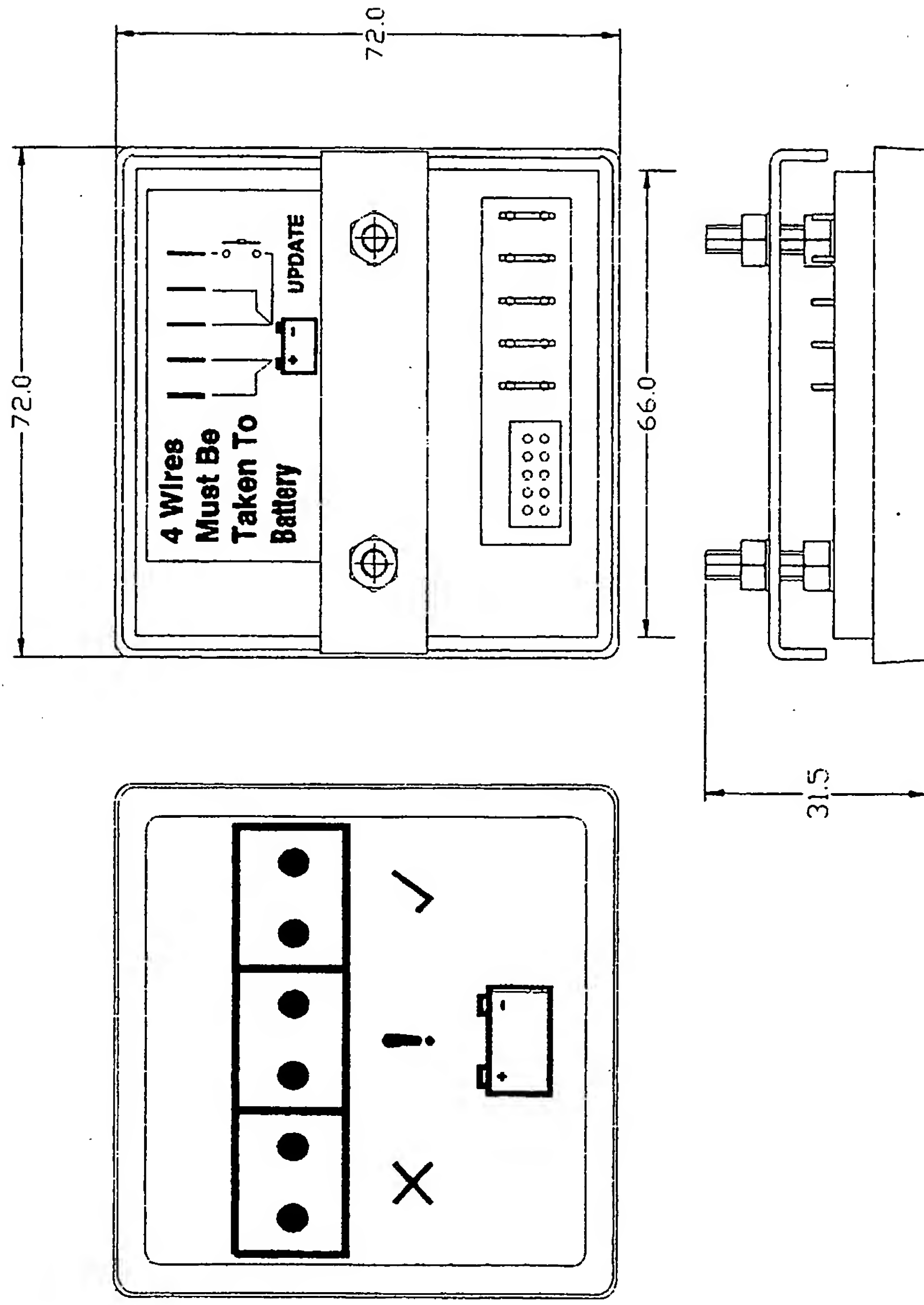




Figure 3



## **Battery "In Service" Health Monitoring Instrument**

The invention relates to an instrument for indicating the health of a battery. Example applications include monitoring starting batteries of engine driven machines and batteries used for energy storage in un-interruptible power supply systems.

It is designed for continuous connection to a battery, either mounted on, or integrated into, the battery casing, or mounted on the machine incorporating the battery. A typical application would be monitoring of engine starting batteries on a piece of agricultural machine such as a tractor.

Instruments for indicating battery voltage, charge and loading are well known (e.g. voltmeter, ammeter). Interpretation of readings requires a technical understanding of the machine electrical system. Even with technical knowledge of the system, instantaneous readings provide little, or no, evidence to determine the health of a battery. An engine driven machine, for example a motorcar, no longer typically includes an instrument for monitoring and indicating battery health, however battery failure remains a common cause of vehicles failing to start.

A service tool is available to check battery performance by applying a high load and monitoring output voltage drop. This instrument is unsuitable for regular use because it uses significant battery charge to carry out the test and the high energy involved requires safe controlled dissipation. This invention avoids these disadvantages.

**Objects of the invention include providing an indication of battery health to**

- Plan preventative maintenance and battery replacement to avoid failure
- Signal imminent failure to enable operators minimise the effects of failure
- Provide information for optimising a cost effective battery replacement strategy

Accordingly, this invention includes a calibration routine to detect performance of a new battery or system. The battery is monitored throughout service life. By comparison with the information stored at time of calibration, an output is provided to indicate health compared with that when the battery and/or system was new.

The instrument is typically housed for installation into a machine instrument panel or housed for mounting adjacent to or within a battery housing. Electronic circuits provide accurate battery terminal voltage detection, occasional battery loading, and mathematical interpretation of detected voltages and storage of reading in non-volatile memory. The indicated output may be by simple coloured indicator (e.g. green, amber, red), through traditional analogue gauge representation, digitally displayed value(s), or may be communicated electronically via a communication port and suitable protocol (e.g. RS485 Canbus).

**Features particularly novel to the invention are**

- The instrument remembers original performance characteristics in order to determine deterioration from readings taken later in service.

- Terminal voltage readings are taken and compared to determine reaction to normal in service loads, load pulses controlled by the invention and battery float voltage.
- Multiple readings are taken in order to detect if conditions are present which may introduce interpretation errors (e.g. charge current pulses, load surges). Readings taken while such conditions are present are discarded.
- Readings taken are combined and compared to provide a reading to indicate a serviceability value for the battery.

### **A Preferred Embodiment**

A preferred embodiment of the invention will now be described with reference to the accompanying diagrams.

Figure 1 – a flow chart illustrating the principle of operation

Figure 2 – schematic of an electronic circuit

Figure 3 – example instrument arrangement incorporating the invention.

### **Principle of Operation**

The instrument takes the following measurements in order to indicate battery condition.

Battery Terminal Voltage

Battery Internal Resistance

Volt Drop over fixed period load.

Battery internal resistance is calculated.

Volt drops occurring in service under operational loads.

### **Calibration**

The installer calibrates the instrument by linking an electrical circuit at the connector provided. Calibration must be carried out with battery fully charged, without a battery charger connected. The first phase of calibration stores battery internal resistance IntCal. The second stage of the test measures terminal volt drop during normal machine operation. To complete this the machine should be put through a normal operating sequence, which uses power from the battery. The instrument measures terminal volt drop experienced and stores the value VdropCal. Once the machine has been operated through a normal operational sequence, the calibration link is removed to resume normal operation.

### **Typical Display Operation**

A six-segment indication may be used to display battery health. A typical example of operation is given below.

The health of the battery is displayed according which indicator is lit. Indicator zero signifying poor health, indicator 4 representing health approximately equivalent to that measured at time of calibration, and indicator 5 signalling an improvement in battery health since calibration.

The instrument will carry out the internal resistance check periodically. A typical period may be once per day, however this may vary according to factors including battery size, application duty cycle

The indicator lit firstly depends on float voltage giving a measure of state of charge. This is then modified according to measured internal resistance, and is further modified according to volt drops recorded in recent service.

#### **Float Voltage Indicator level example.**

Vfull is the measured battery terminal voltage at time of calibration. Voltage indication span calibrated indicator points, (volts in brackets for 12.7v full charge off charge/load) are: -

Indicator 5 On	Vbat > 107% Vfull	(13.59v)
Indicator 4 On	Vbat > 98% Vfull	(12.44v)
Indicator 3 On	Vbat > 94% Vfull	(11.94v)
Indicator 2 On	Vbat > 90% Vfull	(11.43v)
Indicator 1 On	Vbat > 86% Vfull	(10.92v)
Indicator 0 On	Vbat < 86% Vfull	(10.92v)

#### **Display modification According to Internal Resistance Measurement**

IntCal is the internal resistance calculated at time of calibration. IntBat is the internal resistance of the battery most recently calculated during the automatic period load cycle test. Before the display is updated, the on segment is modified as follows

IntBat <= 120% IntCal	No change to health indication.
IntBat >= 120% IntCal and < 150% IntCal	Indicated lower by one segment
IntBat >= 150% IntCal and < 200% IntCal	Indicated lower by two segments
IntBat >= 200% IntCal and < 300% IntCal	Indicated lower by three segments
IntBat >= 300% IntCal	Indicated lower by four segments

Depending on battery type and duty, the above figures may be modified during manufacture to accommodate different health characteristics of the installation.

#### **Display modification According to Measured In Service Volt Drop**

VdropCal is the maximum-recorded volt drop in normal operation during calibration. VdropBat is the maximum volt drop recorded in recent service averaged over the last 5 recorded volt drop events.

VdropBat <= 120% VdropCal	No change to health indication.
VdropBat >= 120% VdropCal and < 150% VdropCal	Indicated lower by one segment
VdropBat >= 150% VdropCal and < 200% VdropCal	Indicated lower by two segments
VdropBat >= 200% VdropCal and < 300% VdropCal	Indicated lower by three
segments	
VdropBat >= 300% VdropCal	Indicated lower by four
segments	



Depending on battery type and duty, the above figures may be modified during manufacture to accommodate different health characteristics of the installation.

### **Example Application**

An example application for the invention is installation onto a boat. The instrument would be integrated into the driver instrument cluster. When the boat is new, or when a new battery is fitted, the calibration routine is invoked to determine "as new" performance. The instrument would then provide the operator with a battery performance indication. Like other traditional instruments that monitor the engine etc. the indication will assist the operator in recognising that a failure may be imminent, and necessary immediate action can be taken to minimise the effects of a possible failure, and maintenance can be planned.



**Claims**

1. An instrument for monitoring and indicating electrical battery performance by comparison of in service performance with that when the battery was new.
2. An instrument as claimed in claim 1 where a combination of terminal voltage, terminal voltage change under load in service, terminal voltage under calibrated load are compared with readings taken at time of calibration and a resultant performance.
3. An instrument as claimed in claim 1 and claim 2 whose output is displayed by a series of indicator lights for battery health signalling.
4. An instrument as claimed in claim 1 and claim 2 whose output is displayed by an analogue gauge, either traditional moving pointer device, or graphical representation of same.
5. An instrument as claimed in claim 1 and claim 2 whose output is displayed by a digital numeric value.
6. An instrument as claimed in claim 1 and claim 2 whose output is delivered to a communications network via a data port.
7. A monitoring instrument substantially as herein described and illustrated in the accompanying drawings.



Application No: GB 0109470.5  
Claims searched: 1-7

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**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H2K (KSX)

Int Cl (Ed.7): G01R (31/36)

Other: Online: EPODOC, JAPIO, WPI

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2121971 A (LUCAS) see p.1 ll.54-94	1
X	EP 0447928 A (MOTO METER) see WPI abstract accession no.1991-282235[41]	1,2
X	EP 0391242 A (ELEKTRON BREMEN) see WPI abstract accession no.1990-306695[41]	1,2
X	FR 2734061 A1 (THOMSON) see p.1 1.31 - p.2 1.12 and WPI abstract accession no.1997-014258[02]	1
X	US 5454710 (LANDAU) see col.2 ll.21-41	1
X	US 4888716 (UENO) see col.5 ll.17-46	1,2,4
X	US 3808522 (SHARAF) see col.1 ll.23-36	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.